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THE UNIT OPERATIONS, PAST, PRESENT AND FUTURE

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ABSTRACT

The creation of the unit operations is one of the paradigms which led to the development of Chemical Engineering in the last century, originating courses, books and numerous articles that prompted the study and creation of equipment and appliances. Then at the sixties appeared the new paradigm of the Transport Phenomena, which addressed the phenomena of momentum, heat and mass transfer from a mathematical and formal point of view. In the seventies the industries began to feel the influence of computers and therefore appeared the courses of simulation and optimization. Since that time it began to run out the books on Unit Operations and on the design of apparatus and equipment. All of the above, in addition to the decrease in the number of semesters of study has impacted on the unit operations courses and has made them disappear little by little in the curricula.

KEYWORDS: Chemical Engineering, Education, Unit Operations

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INTRODUCTION

Modern industrial societies are the result of the great industrial revolution, which began in England in the 18th century and that forever changed the methods used by the mankind to manufacture substances and machines.

Prior to those years the industry was mostly craft and the processes employed techniques that had passed from parents to children for generations. In the 19th century the chemistry had a great development thanks to the great scientists who laid the foundations for the establishment of theories and laws that govern that science.

In that century, the chemists began also to create, at high speed, new chemical substances that had great importance in the industrial development of those times, such as the pigments, fuels, solvents, the rubbers, explosives and drugs .

At that time the creation of new chemical plants was in charge of chemists and mechanical electrical engineers , but towards the end of the 19th century it was realized the need for engineers who knew chemistry and which could engage in the ever more pressing task of designing more efficient chemical plants for substances that had never before been produced commercially.

It was so that in 1887, Edward Davis, in Manchester U.K., proposed the creation of a special career in a series of conferences (Davis, 1888). After Davis´s courses, the idea passed to the United States, where in 1888 were held at MIT the first chemical engineering courses organized by Lewis.M. Norton, Professor of industrial chemistry.(Hougen 1943)

The first curricula settled did stress upon the deep study of chemistry and physics, reinforced by mechanical engineering courses and descriptive courses of the industrial equipment used at that time, as well as the most important industrial processes.

As soon as the graduates began to become operational, they realized the inoperative of their training. The courses received were descriptive and upon arriving at their works the engineers were required to do engineering. They needed to know how to perform balances of matter and energy, how to design equipment, how to determine the size of a new plant, etc. This served to redesign in the schools the teaching of chemical engineering. (Valiente, 2012).

The first thing discovered was the importance of having good balances of matter and energy. In the chemistry courses then only talked about the stoichiometry, but what chemical engineers needed was beyond what was taught in those courses, because the complexity of chemical plants required balances in reactors , distillation columns, purges, processes in transient and permanent regime, etc. Therefore since the beginning of the century the professors began to give courses on balances of matter and energy for engineers, that is considered the first paradigm of chemical engineering (Valiente, 2014). During the first and second of the 20th century appeared the first books that dealt with matter and energy balances. (Lewis,1926), (Hougen 1979).

Appearance of the Unit Operations

With the grow of the chemical industry and when the first engineers leave the schools they discovered the futility of imparting knowledge through the descriptive method and they emphasized the study of the "unit operations" techniques. This concept due to Arthur D. Little, indicates that instead of studying the different processes the engineers should study the operations common to many of them, for example, heat flow, flow of fluid, filtration, distillation, drying, etc.(Little,1993)

These unit operations have as a common property that they are physical and chemical operations, i.e. that they do not involved chemical reactions, but physical or physic chemical processes.

The first engineers had great difficulties with the design of chemical plants, as there was a great lack of data on variables such as viscosity, density, thermal conductivity, diffusivity, heat capacities, etc. The civil and mechanical engineers had only done in-depth studies about fluids such as water and air, but chemical engineers had to work with a huge number of them.

The chemists were not interested in obtaining the thermodynamic and kinetic constants required, so chemical engineers had to be given to the task of obtaining them. For this reason almost all universities and techs in the United States began to do serious studies on the behavior of the equipment used in the chemical industry, and soon there was sufficient information to appear the first book on unit operations: "Principles of the engineering chemistry", Walker, Lewis and Mc Adams, in 1923. (Walker,1934)

In 1934 appeared the first edition of a formidable book, the Manual of the Chemical Engineer of John H.Perry. (Perry, 1934)

Then during the forties and fifties appeared numerous books about unit operations or about some of them, in particular such as those of Badger, Mc Cabe, Brown, Foust, Kern, Treybal, etc.

All these books had a great influence on the development and on the teaching of chemical engineering and formed what is known as the second paradigm (Valiente, 2014).

Transport Phenomena

Over time it became apparent that there were principles common to all the unit operations,principles that sat the

scientific basis of chemical engineering unit operations.

The development of the chemical engineering after the second World War saw the gradual depletion of conventional unit operations research. This led to a new paradigm for chemical engineering, started by the advance of scientific engineering. Unhappy with the empirical description of the operation of processing equipment, chemical engineers began to re-examine the unit operations from a more fundamental point of view. The phenomena that occur in the unit operations were reduced to a sets of molecular events. Quantitative mechanical models of these events, which were used to analyze the existing equipment and the design of new processing equipment were developed. The study of these principles gave rise to a book that changed the study of chemical engineering Transport Phenomena of Bird, Ligthfoot & Steward. (Bird, 1960). That book was followed by many others related to the subject, as those of Welty, Theodor, Rohsenow, Fahien, etc. From the study of transport phenomena the chemical engineering texts changed their orientation and becoming increasingly more mathematical, more fundamental and less oriented towards the calculation and the design; this last also was encouraged by the use of computers that allow programs written in floppy disks perform the necessary calculations for the design of most of the equipment used in the chemical industry and even create the required plans.

The Computer

Since the end of the 1960s the use of computers became more and more intensive, but due to their size and the poor availability of them, it use was related only to the industry and research. When it appeared the first P.C. this produced a change and the computers could soon be used to give classes, do homework, and solve problems that previously seemed unassailable. The use of computers changed the education of chemical engineers. Due to the intensive use and the access to them that had almost all students it was possible to create new fields of study such as: optimization, control, analysis of processes, simulation, etc.

Since then, the use and development of simulators and plotters allowed more accurate and rapid calculations. The computers were employed to calculate physicochemical processes, the balances of mass and energy, the resolution of the equations of state, the design of reactors and design in general. There were many books that appeared to support these courses such as those of Alan and Myers, Himmelblau, Holland, Quantrille etc.

The chemical engineering teachers began to use and develop their classes with simulators, most with processes in steady-state. Gradually they began to use optimization and parallel systems,dynamic and simulators were developed to explore the control of processes in the unsteady state most widely used in the pharmaceutical and fine chemical industry. During the rest of the century, the emphasis on education in the design was in the simulation, process synthesis, design teams and costs and optimization.

The EPPT

In parallel to the progress of scientific engineering evolved the curriculum core of chemical engineering, until reaching its current state. The core curriculum, perhaps more than any other factor, is responsible for the confidence with which chemical engineers integrate the knowledge of many disciplines in the solution of complex problems. This training has enabled the chemical engineers to acquire protagonism in interdisciplinary areas such biochemical engineering, electrochemical engineering, metallurgical engineering, environmental engineering, etc.

The success of the teaching of chemical engineering and the development of fields such as matter and energy balances, unit operations, transport phenomena, the design of reactors, etc. has made that these disciplines were

appropriated by other engineering such as the already mentioned. Nowadays the engineers refers to a discipline mother who could be called the Engineering of the Processes in Physicochemical Transformation (EPPT). (Coeuret, 1992) The EPPT functions as a methodology tank connected to a peripheral network of application sectors. Each sector has its own characteristics, but it is clear that they can connect through the EPPT. So it is that today's Chemical Engineering is related to the biochemical engineering, the environment, the metallurgical and vice versa.

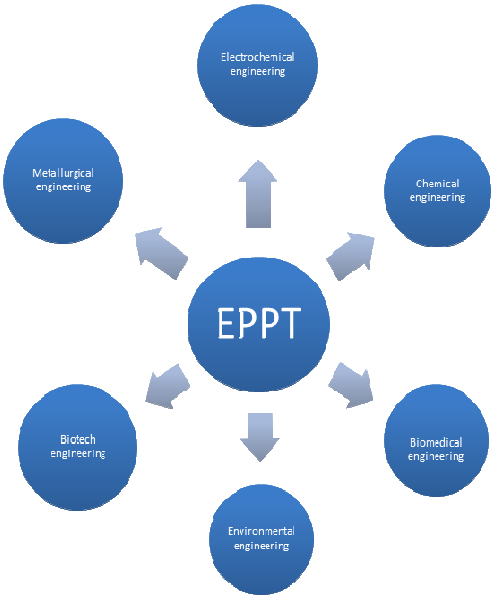

Figure 1

New Trends in Chemical Engineering Teaching

Since the appearance of the Transport Phenomena the influence of unit operations in chemical engineering education has been declining. At that time some universities decided to dismantle its unit operations laboratories, indicating that they were no longer necessary for the formation of new engineers. Those decisions caused many problems to graduates, who dominated the mathematics related to the transfer of momentum, heat and mass, but were unaware of the behavior of the equipment and unit operations, so the manufacturers protested and the universities had to redeploy some courses, especially those related to the so-called mass transfer operations.

The intensive use of computers and simulators also have had impact on the unit operations courses, because according to the promoters of these techniques it was not longer needed more knowledge about the calculation and design of the equipment, since it is all part of the program. Unfortunately this has led to what is known as black boxes, the students only enter data and get results, but they are unaware of how those calculations were conducted and whether they are successful or not.

Paradoxically in other fields of engineering such as food engineering and environmental engineering the unit operations are taking new applications and interest.

Something that has also affected the teaching of unit operations is the large number of new fields of interest occurred in the chemical industry such as the emerging technologies which include biotechnology, genetic engineering, microelectronics, space engineering, robotics, the specialty chemicals,agrochemicals, industrial and environmental safety, kinetics, thermodynamics of reactions and chemical balances , etc.

CONCLUSIONS

The work market for chemical engineers is in constant change. Traditional works on operation, design, selection of equipment and construction is scarce. Most design is shifting to the use of computers in countries where labor is cheaper. The industries require of creative engineers and of their business skills, knowledge of languages, and their ability to bear the frequent technological and economic changes. The current chemical industry is no longer focused on the production of simple chemical and petrochemical products (commodities). The large petrochemical complexes have migrated to oil-producing countries. The emphasis in developed countries is in the production of specialty chemicals, which require changing and sophisticated technology and require relatively modest facilities. Given the globalization and the homogenization of the curricula that can be indicated , the studies for the Bachelor's degree in chemical engineering will be reduced , which will lead to a four-year courses and with very similar curricula to facilitate the exchange of students.

The above will reduce the time for the study of the unit operations and in many cases they will be suppressed. To deal with the suppression of the theory on unit operations the laboratories of unit operations could use to give the minimum of information and skills on these subjets. In the near future the curricula must be modified so that they conform to the teaching competency. We do not expect the publishing of new books about unit operations and on equipment design. Only the companies engaged in the design of appliances will continue to investigate and promote new designs.

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